

# VMT & CO2 Emission Reduction Calculators

*CA MPO Future Mobility Research Program  
Task Order 3*



SCAG Mobility Innovations Working Group – October 24, 2018

## Need and Purpose

- Account for the CO2 emission reductions expected from TDM programs and emerging mobility strategies
- Estimate emissions for strategies that are outside the domain of the regional travel demand model
- Sensitive to growth forecast and transportation investments committed to as part of the Regional Transportation Plan

## Strategies Addressed with Off-Model Calculators in Previous Regional Plans

Strategy	SANDAG	MTC	SCAG	SACOG
Car Share	✓	✓	✓	✓
Vanpool Programs	✓	✓		✓
Carpool Programs	✓			
PEV Charging Stations	✓	✓	✓	✓
Managed Lane Automation	✓			
Transit Managed Lane Automation	✓			
Neighborhood Electric Vehicles			✓	
Ride-sourcing			✓	
Commuter Benefits Ordinance		✓		✓
Employer Shuttles		✓		
PEV Incentive and Vehicle Buyback		✓		
Feebate Program		✓		
Smart Driving		✓		
Targeted Transportation Alternatives		✓		
Trip Caps		✓		
Bike Share		✓	✓	
Bicycle Infrastructure		✓	✓	
Traffic Operations and Management				✓
Telecommute   Work from home				✓

## **SANDAG Off-Model CO2 Calculators**

- Vanpool Program
- Carshare
- Bikeshare
- Pooled Rides
- Microtransit

## Common Features

- Trip and VMT reductions based on local data (when available)
- Travel behavior assumptions drawn from published research and aggregate statistics gleaned from mobility service operators
- Reflect Regional Plan growth forecast assumptions
- Reflect travel behavior outcomes of the Regional Plan (i.e., the model outputs)
- Utilization forecast sensitive to travel time and trip cost
- Geographic differentiation of sub-regional markets

## Vanpool Program

Strategy Element	Emission Reduction Approach & Principal Assumptions
Current and future markets	<ul style="list-style-type: none"><li>▪ Trip origins/destinations from active vanpools inventory</li><li>▪ Three main submarkets – federal military employers, federal non-military, non-federal</li><li>▪ Includes trips that start outside San Diego County (but takes credit for VMT within SDC only)</li></ul>
Growth	<ul style="list-style-type: none"><li>▪ Proportional to employment growth</li><li>▪ Incentivized by investments in regional managed lanes (travel time savings)</li><li>▪ Incentivized by lease cost subsidies</li></ul>
Average VMT, vehicle occupancy	<ul style="list-style-type: none"><li>▪ As reported by active vanpools</li></ul>
Mode in lieu of vanpooling	<ul style="list-style-type: none"><li>▪ Single-occupant vehicle</li></ul>
Emission rates	<ul style="list-style-type: none"><li>▪ SANDAG ABM 14.0.0</li></ul>

## Employment Growth Driver

ORIGIN	DESTINATION												TOTAL
	CTRL	NCITY	SSUB	ESUB	NCWEST	NCEAST	ECNTY	RV	OR	IM	SB	LA	
CENTRAL	2	23	1	0	9	3	1	1	1	0	0	0	41
NORTH CITY	15	22	2	0	15	1	3	1	0	2	0	0	61
SOUTH SUBURBAN	13	46	0	2	8	2	5	0	0	1	0	0	77
EAST SUBURBAN	24	31	1	0	5	1	16	0	1	3	0	0	82
NORTH COUNTY WEST	5	7	0	0	2	0	0	0	3	0	0	0	17
NORTH COUNTY EAST	13	19	1	1	4	2	2	0	1	0	0	0	43
EAST COUNTY	2	1	0	0	0	0	4	0	0	0	0	0	7
RIVERSIDE COUNTY	130	107	10	4	61	12	0	n/a					324
ORANGE COUNTY	2	6	0	0	9	0	0						17
IMPERIAL COUNTY	17	1	0	0	0	0	10						28
SAN BERNARDINO COUNTY	1	1	0	0	0	0	0						2
LOS ANGELES COUNTY	0	1	0	0	0	0	0						1
<b>TOTAL</b>	<b>224</b>	<b>265</b>	<b>15</b>	<b>7</b>	<b>113</b>	<b>21</b>	<b>41</b>	<b>2</b>	<b>6</b>	<b>6</b>	<b>0</b>	<b>0</b>	<b>700</b>

Vanpools grow proportionally with employment in each MSA

## Travel Time Savings Growth Driver

	DESTINATION												
ORIGIN	CTRL	NCITY	S SUB	E SUB	NCWEST	NCEAST	ECNTY	RV	OR	IM	SB	LA	TOTAL
CENTRAL	2	23	1	0	9	3	1	1	1	0	0	0	41
NORTH CITY	15	22	2	0	15	1	3	1	0	2	0	0	61
SOUTH SUBURBAN	13	46	0	2	8	2	5	0	0	1	0	0	77
EAST SUBURBAN	24	31	1	0	5	1	16	0	1	3	0	0	82
NORTH COUNTY WEST	5	7	0	0	2	0	0	0	3	0	0	0	17
NORTH COUNTY EAST	13	19	1	1	4	2	2	0	1	0	0	0	43
EAST COUNTY	2	1	0	0	0	0	4	0	0	0	0	0	7
RIVERSIDE COUNTY	130	107	10	4	61	12	0	n/a					324
ORANGE COUNTY	2	6	0	0	9	0	0						17
IMPERIAL COUNTY	17	1	0	0	0	0	10						28
SAN BERNARDINO COUNTY	1	1	0	0	0	0	0						2
LOS ANGELES COUNTY	0	1	0	0	0	0	0						1
TOTAL	224	265	15	7	113	21	41	2	6	6	0	0	700

- Vanpool demand increases with increasing travel time savings resulting from managed lane investments
- Elasticity-based growth

## Vanpool VMT and CO2 Inputs

Variable		Notes
<b>Baseline number of vans (2016)</b>		SANDAG Vanpool Program Data. Active vanpools as of June 30, 2018. Salesforce report.
Military	251	
Federal Non-Military	109	
Non-Federal	340	
<b>Current vanpool operations</b>		
Avg. round trip mileage, total		SANDAG Vanpool Program Data. Active vanpools as of June 30, 2018. Salesforce report.
Military	125	Includes distance traveled outside of San Diego County
Federal Non-Military	134	
Non-Federal	104	
Avg. round trip mileage, San Diego County		Vanpool distance traveled within San Diego County.
Military	108	Out-of-county distance approximated based on home zipcode coordinates.
Federal Non-Military	122	
Non-Federal	88	
Average van capacity (seats)		SANDAG Vanpool Program Data. Active vanpools as of June 30, 2018. Salesforce report.
Military	7.5	
Federal Non-Military	7.9	
Non-Federal	8.1	
Average occupancy		Average share of occupied seats, including the driver. Based on Vanpool Survey for National Transit Database Reporting, FY 2017/2018. The survey did not collect information about workers' industry, therefore using program average for all industries.
Military		
Federal Non-Military		
Non-Federal		
All vanpools	73%	

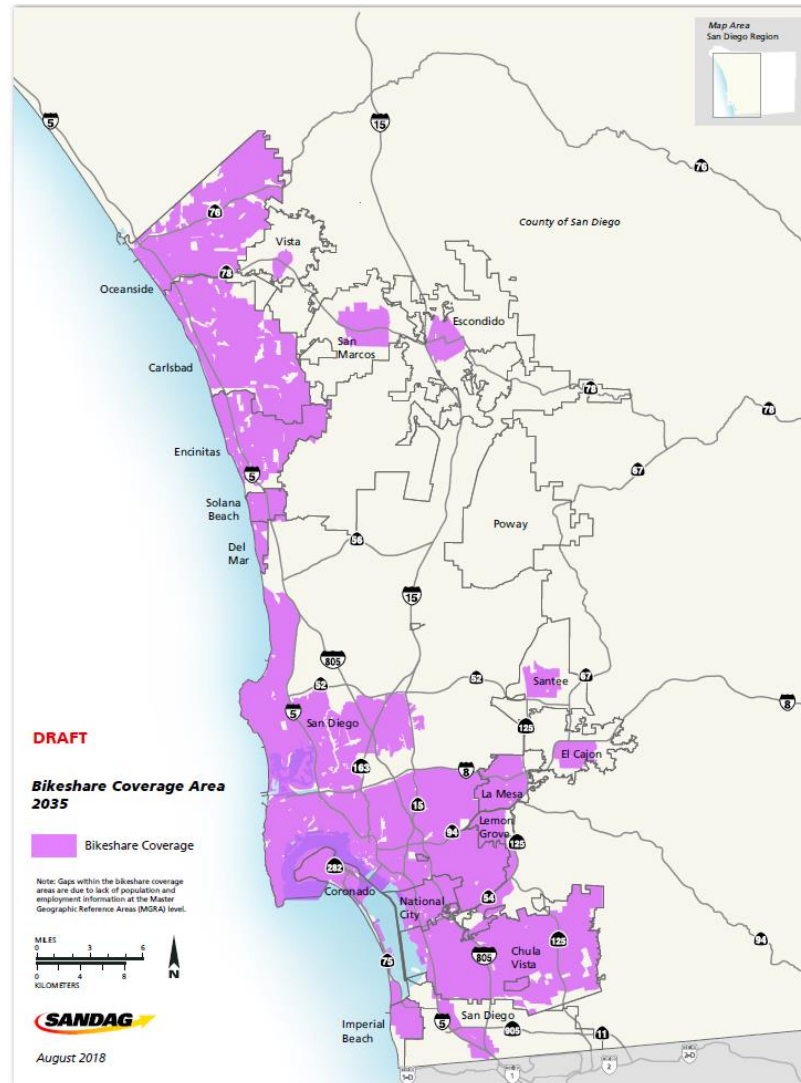
# CO2 Emission Reduction Reporting

Variable	2016	2020	2025	2035	2050	
Total daily vehicle trip reduction	6,605	7,953	8,230	9,200	10,255	= total vans * average occupants (exc. driver) * 2 trips per day
Total daily VMT reduction	382,084	461,096	476,411	532,184	592,994	= total vans * average occupants (exc. driver) * round trip mileage, trip total
VMT reduced in San Diego County	330,534	398,889	412,133	460,584	513,553	= total vans * average occupants (exc. driver) * round trip mileage within San Diego
GHG reduction due to cold starts (short tons)	0.5	0.6	0.6	0.7	0.7	= vehicle trip reduction * trip starts GHG emission factor
GHG reduction due to VMT (short tons)	141.1	164.8	168.4	185.0	205.6	= VMT reduction * running GHG emission factor
Total GHG reduction (short tons)	141.6	165.4	169.0	185.7	206.4	= trip + VMT GHG emission reduction
Total population	3,316,192	3,418,965	3,540,407	3,747,159	4,004,674	
Per capita GHG reduction (lbs/person)	-0.085	-0.097	-0.095	-0.099	-0.103	= GHG emissions (in tons) * 2000 lbs per ton / population
Per capita GHG reduction, relative to baseline	-0.43%	-0.50%	-0.49%	-0.53%	-0.56%	= percent change in per capita GHG reduction

## Bikeshare

Quantity	Overall Approach	Inputs and Source
<b>Market / Market Growth</b>	<ul style="list-style-type: none"> <li>Estimate utilization from experience of bikeshare systems in operation in U.S. cities</li> </ul>	<ul style="list-style-type: none"> <li>Coverage area</li> <li>Population in coverage area</li> </ul>
<b>Supply</b>	<ul style="list-style-type: none"> <li>Number of bikes per 1,000 persons</li> </ul>	<ul style="list-style-type: none"> <li>Bikeshare Planning Guide</li> </ul>
<b>Supply</b>	<ul style="list-style-type: none"> <li>Estimate increase in bikeshare trips due to new bike lane miles</li> </ul>	<ul style="list-style-type: none"> <li>Approximately 100 bike trips induced for each additional bike lane mile (Xu and Chow, 2018)</li> </ul>
<b>Program VMT</b>	<ul style="list-style-type: none"> <li>VMT reduction estimated based on substitution rate of auto trips, and average bikeshare trip length</li> </ul>	<ul style="list-style-type: none"> <li>Inputs obtained from reported data for various U.S. bikeshare systems:</li> <li>Differentiate utilization of traditional bikes and e-bikes</li> </ul>

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# Bikeshare Trip Demand

Bikeshare Strategy Inputs & Assumptions -- Year 2035												
MSA	Proposed Bikeshare Areas							Bike Infrastructure Investments			e-Bike Fleet	
	Number of MGRAs in bikeshare coverage area	Total population in MSA (thousands)	Population in bikeshare coverage area (thousands)	Bikes / 1,000 population <sup>[1]</sup>	Estimated bikeshare fleet size	Daily trips / bike <sup>[2] to [12]</sup>	Estimated daily bikeshare trips	Bikeways (miles)	Additional bikeway miles with respect to base year	Additional bikeshare trips per bikeway mile <sup>[13]</sup>	Number of e-bikes in bikeshare	Percent of e-bikes in bikeshare
	<i>Coverage is defined in Model Data</i>				<i>Population * (Bikes/1000 persons)</i>		<i>Daily trips per bike * daily bike supply</i>	<i>Input lane miles here</i>		<i>102 bikeshare trips per new bikelane-mile</i>	<i>Bikeshare fleet * % e-bikes</i>	<i>Input e-bike supply here</i>
Central	4,368	836	828	10	8,278.40	2.3	19,129	215	51	5,215	4,139	50%
North City	1,552	893	277	10	2,771	2.3	6,403	460	25	2,574	1,385	50%
South Suburban	966	509	385	5	1,923	1.2	2,222	186	8	791	962	50%
East Suburban	839	518	156	5	779	1.2	900	185	9	969	390	50%
North County West	2,601	437	349	5	1,746	1.2	2,017	336	14	1,451	873	50%
North County East	415	511	96	5	478	1.2	553	183	8	788	239	50%
East County	-	43	-	0	-	-	-	38	-	-	-	0%
<b>Total</b>	<b>10,741</b>	<b>3,747</b>	<b>2,090</b>		<b>15,976</b>		<b>31,224</b>	<b>1,603</b>	<b>116</b>	<b>11,788</b>	<b>7,988</b>	

## Bikeshare VMT and CO2 Inputs

Variable	2016	2020	2025	2035	Notes
Percent of electric-assisted bikes and scooters	50%	50%	50%	50%	Asserted by SANDAG staff, partly based on e-bike data provided by Lime, and expected trend towards more electric assisted devices in the future.
Car substitution rate (regular bikes)	20%	20%	20%	20%	Average car substitution rate from bikeshare systems reporting data. See data synthesis in Bikeshare Utilization Data tab.
Average trip distance (regular bikes)	2.0	2.0	2.0	2.0	Model-estimated average trip distance of bike trips. Average bike trip distance in San Diego during ofo's first month of operations is approx. 2 miles (reported to SANDAG). Average trip distance for station-based bikeshare deployed for transit integration varies in the 1.3 to 2.4 mile range (TCRP Synthesis # 132).
Car substitution rate (e-bikes)	37%	37%	37%	37%	Data from European systems shows that average trip distance of e-bike is more than double the trip distance of regular bike users.
Average trip distance (e-bikes)	4.0	4.0	4.0	4.0	North American e-bike users report car substitution rates of 37% for non-commute trips and 64% for commute trips. Average trip distance of trips that would have been made by car is 9.3 miles.
Projected daily bikeshare trips (regular bikes)	0	13,998	15,757	21,506	<i>Calculated in Bikeshare Demand tab, based on bikeshare coverage, population and utilization</i>
Projected daily bikeshare trips (ebikes)	0	13,281	15,754	21,506	<i>= total bikeshare trips * proportion of e-bikes in bikeshare fleet</i>
Regional population	3,316,192	3,418,965	3,540,407	3,747,159	<i>From Model Data tab (for per capita calculations)</i>

## Carshare

Quantity	Overall Approach	Inputs and Source
<b>Market / Market Growth</b>	<ul style="list-style-type: none"> <li>Estimate future carshare users based on population living in areas dense enough to support carsharing.</li> <li>Markets: <ul style="list-style-type: none"> <li>Employment Centers</li> <li>Colleges and universities</li> <li>Military bases</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Coverage areas</li> <li>Driving-age population</li> <li>College enrollment and employment</li> <li>Participation rates (2% in urban areas and 0.5% in suburban areas based on data from the Puget Sound Region (Petersen et al, 2016).</li> <li>Urban and suburban density thresholds</li> </ul>
<b>Program VMT</b>	<ul style="list-style-type: none"> <li>VMT reduction based on case study data</li> </ul>	<ul style="list-style-type: none"> <li>7 miles per day, traditional carshare (Cervero et al, 2007)</li> <li>1.1 miles per day, one-way (Martin and Shaheen, 2016)</li> </ul>

## Carshare Membership

	Strategy Inputs -- Year 2035						
	General Population						
MSA	MGRAs in coverage area	Eligible Population (thousands)	Eligible urban population (thousands)	Eligible suburban population (thousands)	Percent of urban population expected to become members [4]	Percent of suburban population expected to become members [5]	Estimated carshare membership
Central	834	162	141	21	2.0%	0.50%	2,921
North City	263	37	32	5	2.0%	0.50%	664
South Suburban	1	-	-	-	2.0%	0.50%	-
East Suburban	3	-	-	-	2.0%	0.50%	-
North County West	86	22	1	21	2.0%	0.50%	118
North County East	5	2	2	-	2.0%	0.50%	35
East County	-	-	-	-	2.0%	0.50%	-
<b>Total</b>	<b>1,192</b>	<b>222</b>	<b>175</b>	<b>47</b>			<b>3,738</b>

## Carshare Membership

Strategy Inputs -- Year 2035												
MSA	Colleges - Staff				Colleges - Students				Military Bases			
	MGRAs in college coverage area	College / University Employment	Percent of employees expected to become members [4]	Estimated carshare membership	MGRAs in college coverage area	College / University Enrollment	Percent of students expected to become members [4]	Estimated carshare membership	MGRAs in military base coverage area	Military Base Employment	Percent of staff expected to become members [4]	Estimated carshare membership
Central	1	351	2.0%	7	1	24,381	2.0%	488	5	32,181	2.0%	644
North City	3	12,949	2.0%	259	3	19,141	2.0%	383	5	9,717	2.0%	194
South Suburban	-	-	2.0%	-	-	-	2.0%	-	-	-	2.0%	-
East Suburban	-	-	2.0%	-	-	-	2.0%	-	-	-	2.0%	-
North County West	-	-	2.0%	-	-	-	2.0%	-	2	21,510	2.0%	430
North County East	1	5,393	2.0%	108	1	10,607	2.0%	212	-	-	2.0%	-
East County	-	-	2.0%	-	-	-	2.0%	-	-	-	2.0%	-
<b>Total</b>	<b>5</b>	<b>18,693</b>		<b>374</b>	<b>5</b>	<b>54,129</b>		<b>1,083</b>	<b>12</b>	<b>63,408</b>		<b>1,268</b>

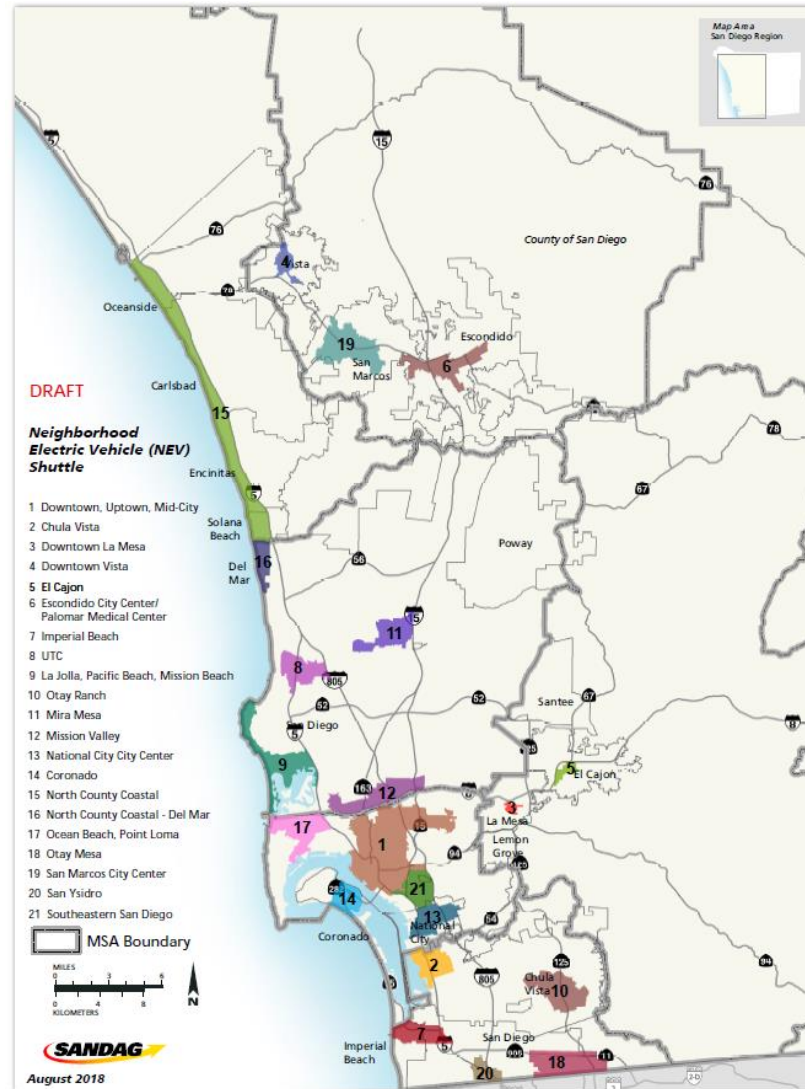
## Pooled Rides

Quantity	Overall Approach	Inputs and Source
<b>Market / Market Growth</b>	<ul style="list-style-type: none"> <li>• Mode shift model applied to drive-alone trips</li> <li>• Model calibrated to aggregate mode shares reported for San Diego County</li> </ul>	<ul style="list-style-type: none"> <li>• SANDAG ABM data               <ul style="list-style-type: none"> <li>○ Drive alone trips predicted in each future year auto ownership category</li> </ul> </li> <li>• 2016-2017 San Diego Regional Transportation Study</li> <li>• 2018 Commute Behavior Survey</li> </ul>
<b>Supply</b>	<ul style="list-style-type: none"> <li>“ Elasticity-based change in demand due to ML travel time savings</li> <li>“ Average trip cost</li> </ul>	<ul style="list-style-type: none"> <li>• SANDAG ABM data               <ul style="list-style-type: none"> <li>○ Average drive alone and carpool travel times</li> <li>○ Average auto operating cost</li> </ul> </li> <li>• Internal Revenue Service               <ul style="list-style-type: none"> <li>○ 2016 mileage reimbursement rate</li> </ul> </li> </ul>
<b>Program VMT</b>	<ul style="list-style-type: none"> <li>• Length of trip that shifts from drive-alone to pooled ride</li> </ul>	<ul style="list-style-type: none"> <li>• SANDAG ABM data               <ul style="list-style-type: none"> <li>○ Average drive-alone trip distance, work and non-work trips</li> </ul> </li> <li>• Average vehicle occupancy</li> </ul>

## Microtransit

- Transit that relies on real-time ride-hailing, tracking and app-based payment
  - e.g., *Free Ride Everywhere Downtown (FRED)*
- Microtransit service envisioned for San Diego County
  - *Expansion of FRED, provided with Neighborhood Electric Vehicles*
  - *Commuter-based service, in areas not well served by fixed-route transit, and serving trips to regional employment centers*

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## Microtransit

Quantity	Overall Approach	Inputs and Source
<b>Market / Market Growth</b>	<ul style="list-style-type: none"> <li>• Mode shift model applied to drive-alone trips</li> <li>• Two types of service, within well-defined coverage areas</li> <li>• Non-competing with fixed-route transit</li> </ul>	<ul style="list-style-type: none"> <li>• Coverage areas</li> <li>• SANDAG ABM data               <ul style="list-style-type: none"> <li>◦ Drive alone trips within the coverage areas</li> </ul> </li> <li>• Fixed-route transit level of service</li> </ul>
<b>Supply</b>	“ For NEV shuttle, fixed mode shares “ For CB shuttles, aggregate mode shift model	“ FRED mode share “ Projected commuter-shuttle travel time and trip cost
<b>Program VMT</b>	<ul style="list-style-type: none"> <li>• Length of trips that shift to microtransit</li> </ul>	<ul style="list-style-type: none"> <li>• SANDAG ABM data</li> </ul>

## Microtransit Mode Shift Model

- Applied to drive-alone trips predicted by the regional travel demand model (SANDAG ABM)
- Filters trips that have good fixed-route transit service
- Microtransit projected to be priced competitively relative to other transit and pooled options
- Travel time projected to be similar to suburban express buses
- All else equal, assumed to be less preferable than fixed-route transit

## NEV Shuttle Demand

Strategy Inputs -- Year 2035									
MSA	NEV Shuttle Service -- Non-Military								
	MSA area (acres)	NEV shuttle service areas (acres)	Proportion of MSA that has NEV shuttle service	Total daily person trips less than 2 miles long in coverage area [3]	Daily auto trips less than 2 miles long in coverage area [3]	NEV shuttle share of all person trips [1],[2]	NEV shuttle daily trips	NEV shuttle auto substitution rate	Replaced auto trips
Central	62,324	15,206	24.4%	364,005	144,778	0.45%	1,638	33%	540.55
North City	184,829	10,108	5.5%	186,348	104,324	0.45%	839	33%	276.73
South Suburban	68,130	8,590	12.6%	98,795	53,099	0.45%	445	33%	146.71
East Suburban	363,195	804	0.2%	5,822	2,727	0.45%	26	33%	8.65
North County West	222,260	7,893	3.6%	55,810	30,539	0.45%	251	33%	82.88
North County East	347,901	1,208	0.3%	8,951	5,084	0.45%	40	33%	13.29
East County	1,478,318	-	0.0%	-	-	0.45%	-	33%	-
<b>Total</b>	<b>2,726,957</b>	<b>43,810</b>	<b>1.6%</b>	<b>719,731</b>	<b>340,551</b>		<b>3,239</b>		<b>1,069</b>

## Commuter-Based Shuttle Demand

Strategy Inputs -- 2020								
Employment Center	Total jobs in employment center	Home to work person trips to employment center	Drive alone work trips to employment center	Drive alone work trips to employment center, from areas with no or poor transit service	Unsubsidized commuter shuttle service		Subsidized commuter shuttle service	
					Home to work trips	Home to work mode share	Home to work trips	Home to work mode share
Downtown San Diego	89,966	59,600	38,378	25,298	1,141	5%	1,740	7%
Sorrento Valley	82,117	51,604	44,794	34,821	1,961	6%	2,879	8%
Kearny Mesa	129,430	74,801	63,013	49,997	2,783	6%	4,104	8%
UTC	87,196	50,291	41,862	28,380	1,387	5%	2,106	7%
East Carlsbad	81,155	55,359	46,465	43,067	2,206	5%	3,228	7%
Mission Valley	46,409	29,642	23,663	18,104	911	5%	1,349	7%
Camp Pendleton	45,437	19,856	17,069	14,234	714	5%	1,040	7%
Naval Base Coronado, Naval Amphibious Base Coronado	17,436	10,110	7,274	5,291	229	4%	343	6%
MCAS Miramar	26,937	14,950	11,028	9,306	416	4%	575	6%
Naval Base San Diego	8,271	4,805	4,202	4,158	139	3%	247	6%
Port of San Diego/ South of Downtown	9,585	5,766	4,423	3,063	160	5%	241	8%
<b>Total</b>	<b>623,939</b>	<b>376,784</b>	<b>302,171</b>	<b>235,719</b>	<b>12,047</b>	<b>5%</b>	<b>17,852</b>	<b>8%</b>

## Some Parting Thoughts

- Many assumptions can (and should) be updated when local data become available ...
- ... and/or as research findings get updated
- All assumptions are exposed and documented
- Coverage areas, densities and similar inputs can be customized by region and RTP investment assumptions
- A few parameters are region-specific (e.g., average value of time, aggregate emission rates)
- Can be adapted to use outputs from a trip-based model

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*The travel demand, VMT, and CO2 emission forecasts shown on this presentation are meant for illustration only; they do not reflect official forecasts of the San Diego Association of Governments.*